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BEET SUGAR: AN INDUSTRIAL WASTE GUIDE TO
THE BEET SUGAR INDUSTRY

Environmental Health Center
Cincinnati, Ohio

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BET SUGAR

An Industrial Waste
Guide to the
Beet Sugar Industry

Review Copy

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INDUSTRIAL WASTE GUIDE

BEET SUGAR

Abstract

Beet sugar is extracted by passing warm water over sliced beets. The resulting solution is partially purified by adding lime together with carbon dioxide and removing the resulting precipitate and suspended material by filtering. Sugar is crystallized out of the purified solution by evaporation. The residual material from evaporation (molasses) may be subjected to further lime treatment (Steffen process) thereby recovering a portion of the remaining sugar as a calcium saccharate. Ion exchange treatment of second-carbonation beet juice is being employed to a limited degree.

Beet sugar factories are generally of capacities sufficient to process 1,000 to 3,600 tons of beets per day. They operate seasonally, for a period of 60 to 100 days beginning in early October.

The major liquid wastes produced in beet sugar manufacture are listed below:

- (1) Flume water used to clean and transport beets.
- (2) Pulp screen water from screening the spent beets (pulp).
- (3) Pulp press water from pressing additional water from drained pulp preliminary to drying.
- (4) Pulp silo drainage from the basins used to store wet pulp (produced only where pulp is not dried).
- (5) Lime cake slurry from filtering the precipitated and suspended material from lime-treated and carbonated juice.
- (6) Steffen waste, the filtrate from filtering precipitated sugar from diluted and lime-treated molasses in the Steffen process.

Representative values of the character and volume of these wastes are

given in Tables 1 and 2. Variations of as much as ± 50 per cent in the pollution load per unit production from certain waste components at different factories have been noted.

Some wastes may be eliminated by modification in operation. Examples are:

- (1) Pressing and drying of pulp in lieu of the pulp silo.
- (2) Continuous diffusers, with mechanical means of transporting to the presses drained pulp as it is withdrawn from the diffuser.
- (3) Facilities for handling lime cake as a moist solid rather than as a slurry.

Other wastes are eliminated by such process changes as:

- (1) Recirculation of flume water after efficient removal of settleable material.
- (2) Return of pulp screen and press water to the diffusion process.
- (3) By-product recovery from Steffen waste.
- (4) Calcining of lime cake.

Treatment of pulp screen and press water with lime in units providing coagulation and sedimentation is effective in removing suspended solids but the effluent remains objectionable. Plain settling of flume water accomplishes similar results. Steffen waste as a coagulant of these wastes has also been employed. These treatment methods are only partial solutions. Further treatment by biological methods is extremely costly. Retention of lime cake waste in lagoons for a short time is an effective treatment method. Short-time retention of other factory wastes in lagoons is unsatisfactory treatment for discharge.

Treatment for disposal is overshadowed in its effectiveness and practi-

cality by recirculation methods previously referred to. Residual liquid wastes from recirculation systems and lagoon supernatant where such cannot be disposed of by leaching into the ground and evaporation may be given biological treatment and discharged uniformly throughout the year.

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Industrial Waste Guide

Beet Sugar

In 1948 beet sugar was produced at 85 plants operating in sixteen states. California, Colorado, and Idaho were the three largest producers. A total of 1,369,000 tons of beet sugar were produced from 9,422,000 tons of beets which represented 12.34% of the world total. Liquid wastes from the beet sugar industry in the United States are conservatively estimated to have a population equivalent potential of 17,000,000.

Description of Process

The process for extracting and refining sugar from beets is basically the same in all beet sugar factories. In 1946, there were 41 Steffen and 40 straight house plants operating in the United States. Beet sugar manufacture is seasonal since there is no practical method of storing beets for long periods of time. The season begins near the first of October and lasts 60 to 100 days. Operation is continuous 24 hours per day. The capacities of beet sugar factories are measured in tons of beets processed per day, plants varying in capacity from 1,000 to 3,600 tons.

Standard Beet Sugar Manufacture

The beets are dug and topped both by machine and by hand. In those areas where cold weather requires early harvesting, the beets are stored in open piles. They are hauled by truck or train to the factory as needed. Figure 1 is a simplified flow diagram showing basic operations of a beet sugar factory. Both straight and Steffen house operations are included.

Beets are conveyed from the railroad cars or the storage area to the plant by means of water flowing in flumes. Devices for removing remaining beet leaves, floating debris, sand and rocks, and a controller for evening out the flow of beets operate along the flume. Transporting of the beets in water in

this manner washes most of the sand and soil from them. The beets are discharged from the flume to a beet wheel, which elevates them to a washer. The water passes on through the wheel to the plant sewer or flume water recirculating system.

The washers are vat-type rectangular chambers, equipped with agitators. Fresh water is admitted and waste water released continuously. Some installations provide a final spray wash of the beets on a conveyor following the washer. Washed beets at some factories are passed over a picking table where spoiled beets and foreign material are removed by hand. Washer waste water is frequently passed through coarse screens to recover small pieces of beets and roots for stock food.

The washed beets are elevated to a weighing apparatus. From the scales they fall to slicers where they are pressed against sets of rotating knives which cut them into long narrow ribbons, V-shaped in cross section, called "cossettes." The cossettes are transported on conveyor belts to the diffuser for extraction of sugar.

Most plants are equipped with the cell type battery although some of the more modern plants employ continuous diffusers. The cell type battery consists of a series of 10 to 14 vertical, cylindrical steel tanks, each of which holds 3 to 7 tons of cossettes. Sugar is extracted by passing hot water through the cossettes, employing the counterflow principle. These cells are connected by an intricate piping system so as to permit the diffusion liquor to pass progressively from one cell to the next in series. The cells are filled with cossettes in rotation and dumped of spent cossettes in similar sequence. Fresh battery supply water enters the cell containing cossettes which have been longest in the system and from which, therefore, most of the sugar has been extracted. The water then passes progressively through cells

which have been under diffusion shorter periods of time and leaves the battery after passing through the cell which has been most recently filled with cossettes. Three cells are usually out of circulation for dumping and filling operations. The liquid drawn from the diffusion battery is known as "raw juice." It contains 10 to 13 per cent sugar and both soluble and insoluble non-sugars.

Cells containing spent cossettes (pulp) are isolated from the circulating system and the contents dumped through a quick-opening gate. The gate may be located either at the bottom center of the cell or on the side of the cell adjacent to the bottom. Adhering pulp and that retained on cossette chain supports is flushed from the cell by battery wash water from high pressure hose. The side-dump type requires considerably more water for flushing than does the bottom-dump type.

The pulp, water contained in the cell when it is dumped, and battery wash water are collected in a flume running the length of the battery. This pulp suspension is pumped to a special type screen, commonly referred to as a "faenger." A large portion of the water drains from the pulp through the faenger.

This pulp constitutes high grade stock feed. At some factories the pulp is stored in the wet state, that is, as drained on the screen, pending feeding. Wet pulp is stored in open pit silos provided with an underdrain system. At other factories, screened pulp is further dewatered in special presses and promptly dried to about 12 per cent moisture in rotary kilns.

Several types of continuous diffusers are in use, most of which have been recently developed and perfected. Although the types differ considerably in design, all employ the principle of countercurrent flow by mechanically moving the cossettes in reverse direction to the flow of diffusion liquor. In con-

tinuous diffuser operation the pulp is delivered from the diffuser in a drained state. At some factories water is deliberately added to the pulp from continuous diffusers in order to form a water suspension that can be pumped to the silo. Use of conveyor belts to transport drained pulp to presses or a silo obviates the need for screening, thus eliminating pulp screen water waste.

The raw juice from the diffusion process is subjected to chemical treatment and filtration which removes a large percentage of suspended matter and 30 to 40 per cent of the non-sugars. In straight house operation, milk of lime is added to the raw juice and carbon dioxide, produced in a lime kiln from limestone and coke, is bubbled through the limed juice. In Steffen house operation, calcium saccharate, from the Steffen process, as described later, is added to the raw juice instead of milk of lime. The precipitate which forms when the juice is limed and carbonated is filtered or settled from the juice. The juice is carbonated a second time, refiltered, and then treated with sulfur dioxide gas and filtered a third time. The material removed by this process is known as lime cake. It is diluted with water and discharged as a slurry.

Sugar is recovered from the partially purified juice by evaporation and separation of resulting sugar crystals, after they have reached the desired size, by centrifuging. The residual molasses is further evaporated and centrifuged a second time and finally a third. Sugar from the second and third crystallizations, being impure, is remelted and returned to the process for recovery in first crystallization. In straight house operation the resulting molasses following third crystallization and centrifuging is shipped to a Steffen house for additional sugar recovery, or is marketed. The most important commercial uses of beet sugar molasses are: yeast manufacture, alcohol production, and as stock food supplement.

Beet sugar molasses normally run about 82% dry solids of which 60 to 63%

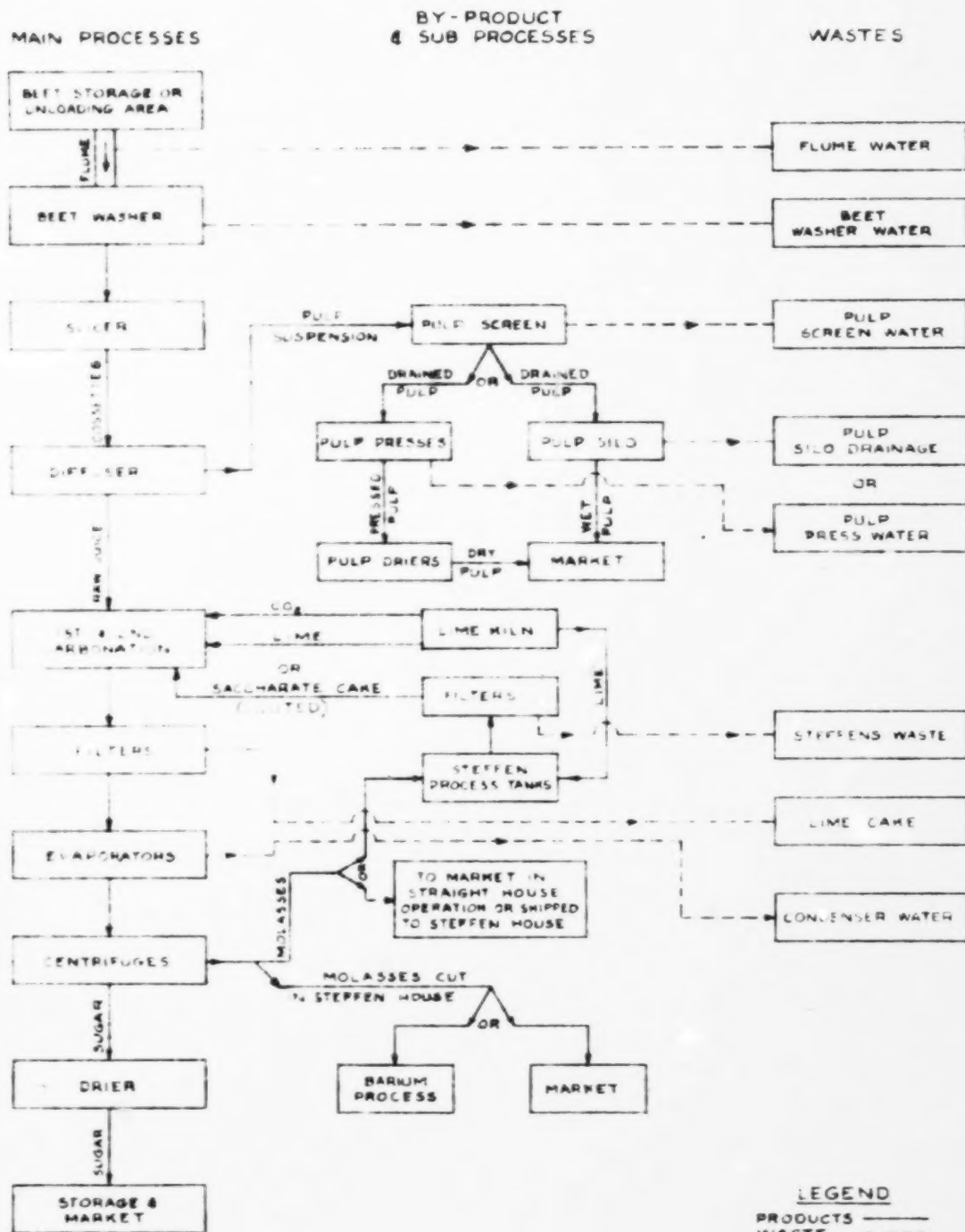
are sugar. In other words every pound of non-sugar which is not removed in either the diffusion or carbonation processes goes into molasses and takes with it one and one-half pounds of sugar. The Steffen process is employed when the additional sugar recovered is of greater value than the molasses and the expense of recovery.

In the Steffen process, molasses from the third centrifuging is diluted and lime is added under carefully controlled conditions. This lime treatment produces a calcium saccharate precipitate which is removed from the dilute molasses by filtering. Some Steffen houses heat the cold filtrate to approximately 75°C. thereby precipitating more calcium saccharate and recover it with a second filtration. The filtrate is known as Steffen waste. The saccharate cake contains, in addition to sugar, both soluble and insoluble non-sugars. It is diluted to a saccharate milk and used for raw juice purification immediately prior to carbonation.

Sugar returned in the saccharate cake is recovered by conventional straight house operation. Non-sugars returned to the process with the saccharate cake become increasingly concentrated in the molasses as the process continues. In order that these non-sugars do not interfere with economical sugar recovery, a portion, or cut, of the third centrifuge molasses is drawn off. Molasses produced at other straight houses (foreign molasses) is processed by most Steffen houses as a means of alleviating the detrimental effect of accumulation of inseparable non-sugars.

The third centrifuge molasses discard, essential in most Steffen houses, is usually marketed. However, it is possible to extract even more sugar as a barium saccharate. One barium extraction plant is in operation in the United States. Unlike the Steffen process, the end liquor from barium extraction is a marketable molasses.

FIGURE 1
FLOW DIAGRAM
BEET SUGAR FACTORY



Ion Exchange Process for Beet Juice

Recent development of the organic or resinous type of ion exchangers provides a means for increasing the efficiency of removal of non-sugars from second carbonation beet juice prior to evaporation and crystallization. The end result is increased sugar yield, a substantially reduced molasses production, and a molasses that can be converted by further ion exchange treatment into an edible product.

The cation exchanger is a granular sulphonated phenol formaldehyde resin possessing the property of exchanging hydrogen ions present in its structure for cations, such as sodium, potassium, calcium, magnesium, and organic cations when in contact with solutions of these salts. The hydrogen ions replace the cations in the solution forming the acids of the various anions. The anion exchanger, or acid adsorber, is a polyamine phenol formaldehyde resin having the capacity to molecularly adsorb or possibly to exchange hydroxyl ions for the anions found in acid-bearing solutions. Consequently, when a sugar solution containing dissolved salts is passed through a bed of cation exchanger, then through a bed of acid adsorber resin, the resulting solution is essentially free of ionizable salts.

Relatively strong sulfuric acid solution is used to regenerate the cation resins. The anion resins are regenerated by washing with an alkali solution composed of sodium hydroxide and ammonia. After the excess regenerants are washed from the resin beds, they are virtually recovered to their original capacity. Three beet sugar refineries in the United States are known to be using ion exchange for treatment of all or a part of sugar beet juices.

Raw Materials and Products

Raw Materials

Raw materials for the processing of one ton of sugar beets are approximately as follows:

Sugar Beets	One ton
Limestone	60-135 lbs.
Coke	5-11 lbs.
Coal	180-280 lbs.
Sulfur	0.5 lbs.
Water	2500-3500 gals.

Diatomaceous earth filter aid.

Sodium carbonate.

Coke is burned in a kiln with the limestone to produce lime and carbon dioxide. Considerably more lime per ton of beets is required in the Steffen house than in the straight house. Coal is used for steam production and for pulp drying. Natural gas may also be used.

Products

Sugar beets vary considerably in sugar content, ordinarily ranging from 12 to 18 per cent. Sugar yield depends upon the processes employed, that is, whether or not the Steffen and barium processes are included. One ton of beets yields from 200 to 300 pounds of refined sugar. Straight house operation extracts 80 to 85% of the sugar from the beet. The Steffen process extracts an additional 10%.

In addition to refined sugar, a number of by-products are produced. Pulp is an important by-product for stock feeding. One ton of beets yields about one ton of wet pulp, 95% moisture, or about 110 pounds of dried pulp 12% moisture. Molasses production from straight house operation is governed by the quality of the beets processed. The quality of beets is dependent in turn on the region in which they are grown. Beets from the Rocky Mountain area yield about 75 pounds of straight house molasses per ton of beets whereas those from Ohio, which contain a higher percentage of extractable non-sugars, may yield 120 pounds. Lime cake is used as fertilizer in certain areas.

Steffen waste from some Eastern and California factories has been processed in recent years for recovery of monosodium glutamate, a taste-intensifying condiment. The waste also contains valuable fertilizer components which were successfully recovered during their high-value period of World War I.

Volume and Character of Wastes

Values considered to be representative of the volume and character of beet sugar manufacturing wastes are given in Tables 1 and 2. Cognizance must be taken of differences in process equipment and other pertinent factors in selecting and applying the values for estimates of waste volume or character at any factory. Detailed discussion of each of the wastes is presented in subsequent paragraphs.

Flume Water Waste

This waste comprises the water used in floating beets from storage or unloading areas to the factory and the waste from the beet washer. It contains large quantities of soil washed from the beet, pieces of beet roots and leaves, trash, and a small quantity of materials in solution. The characteristics depend considerably on the type of soil in which the beet is grown, the nature of the weather during harvest, and the extent of spoilage in the stockpile. Wet weather during harvest may be expected to increase the quantity of soil and silt carried on the beets. One investigator found certain characteristics of this waste to triple in value over the season due to freezing and deterioration of the beets.

Suspended solids are most variable with values as high as 4,300 and as low as 800 parts per million having been observed. Flume water biochemical oxygen demand may be expected to vary between 150 and 250 parts per million. The volume of flume water at different factories ranged from 2,100 to 3,100 gallons per ton of beets.

TABLE 1. REPRESENTATIVE VALUES OF CHARACTER AND VOLUME OF BEET SUGAR MANUFACTURING WASTES

Waste	Flow, per ton of beets, gallons	Biochemical Oxygen Demand 5-Day, 20° C.	Suspended Solids	5-Day B.O.D. per ton of beets sliced, Pounds
		Parts per million.		
<u>Flume Water</u>	2,600	210	800-4300	4.5
<u>Pulp Screen Water</u>				
Bottom dump cell- type diffuser	240	980	530	2.0
Side dump cell- type diffuser	1,420	500	620	5.9
Continuous dif- fuser (1)	400	910	1,020	3.0
<u>Pulp Press Water</u>	180	1,710	420	2.6
<u>Pulp Silo Drainage</u>	210	7,000	270	12.3
<u>Lime Cake Slurry</u>	90	8,600	120,000	6.5
<u>Lime Cake Lagoon Effluent</u>	75	1,420	450	0.89
<u>Condenser Water</u>	2,000	40		0.67

TABLE 2 - STEFFEN WASTE CHARACTER AND VOLUME

Waste	Flow, per ton of Molasses (2) Processed, Gallons	Biochemical Oxygen Demand 5-Day, 20° C. ppm	Suspended Solids ppm	5-Day B.O.D. per ton of Molasses Worked, Pounds
Steffen	2640	10,500	100 to 700	231

- (1) Water transported pulp in lieu of mechanical conveyor.
 (2) Converted to 50% Sucrose (sugar) Basis.

Suspended solids are most variable with values as high as 4,300 and as low as 800 parts per million having been observed. Flume water biochemical oxygen demand may be expected to vary between 150 and 250 parts per million. The volume of flume water at different factories ranged from 2,100 to 3,100 gallons per ton of beets.

Pulp Screen Water

This waste is drained from the pulp through a screen. It is comprised of water contained in each cell when it is isolated from the diffusion circuit for dumping, plus water used to flush out the cells and, in certain cases, water added to create a pulp suspension for pumping to the screen. It contains finely divided pulp in suspension, organic material in colloidal suspension, and a comparatively large amount of sugar and other organic material in solution. The sucrose content has varied between 300 and 600 ppm. A small amount of sand from the beets is also present. The amount of pulp present is dependent on the fineness of the screen. This waste has a temperature of about 50° C.

The concentration of the waste is dependent to a considerable extent on the type of diffuser. Diffusers requiring large volumes of wash water give a relatively dilute waste but the over-all pollution load is increased. The biochemical oxygen demand varies between 500 and 1,000 ppm depending on the type of diffuser. The B.O.D. of daily composites may vary as much as 50% from the average. Pulp screen water from one plant with bottom dump diffuser cells had an average 5-Day B.O.D. of 980 ppm following screening through a 30 x 40 mesh vibrating screen.

Pulp Press Water

At factories where pulp is dried, the screened pulp is further dewatered in presses before drying. The water pressed from the pulp constitutes pulp press water. The characteristics of pulp press water vary with the physical quality

of the pulp. They are similar to pulp screen water with somewhat higher solids and B. O. D. The sucrose content may average as much as 2,100 ppm. Pulp press water amounts to some 180 gallons per ton of beets with a B.O.D. averaging 1,700 ppm.

Pulp Silo Drainage

The liquid drains from wet pulp during storage in open silos. The volume varies with the quantity of pulp stored, efficiency of the pulp screen, fermentation, and rainfall. The volume per ton of beets at two factories averaged 165 and 270 gallons, respectively. Daily flow varied as much as 30% from these average values. The B.O.D. of these same wastes averaged 8,800 and 6,000 ppm, respectively, with daily composites varying as much as 50% from the averages. Organic acids of decomposition create a pH of about 4 in this waste.

Pulp silo drainage is the one waste which does not cease at the end of factory operation. In fact it may become stronger if pulp remains in the silo until warm weather. Data given in table 1 for silo drainage are for the period the factory was operating.

Lime Cake Slurry

Lime cake forms when lime-treated and carbonated juice is filtered. It is common practice to dilute the cake with water to form a slurry which can be pumped. The amount of water added to the cake is dependent to some extent on the type of filter and the operator. This factor must be considered in comparing volumes and concentrations of the waste. Lime cake waste has been reported to average from 6,850 to 10,250 ppm B.O.D. and 107,000 to 137,000 ppm suspended solids. The pH of the waste is about 11.7.

The pollution load per ton of beets in this waste is greater for a Steffen house than for a straight house. Available data indicate a population equivalent value of 49 for Steffen house and 26 for straight house lime cake slurry. This indicates materials return with the saccharate from the Steffen process

which are removed in the lime cake. Accepting this premise, it will be evident that lime cake waste from a Steffen house will be influenced by the amount of molasses worked.

Steffen Waste

The filtrate produced in filtering saccharate cake from lime-treated diluted molasses in the Steffen process is known as "Steffen Waste." Since Steffen plants process varying amounts of foreign molasses in addition to their own, it is desirable to express Steffen waste on the basis of molasses worked. Steffen waste is reasonably uniform in volume and concentration as will be appreciated from the following considerations.

Beet sugar molasses contains 60 to 63 per cent sucrose (sugar) dry solids basis. This relation between sugars and non-sugars holds whether the molasses is produced in a straight house or a Steffen plant. On a total weight basis, molasses is about 50 per cent sucrose. It is customary in the industry to convert molasses to a 50 per cent sucrose basis which likewise reduces the non-sugars to a common basis.

In Steffen house operation, the calcium saccharate returned to process carries with it inseparable non-sugars. These non-sugars tend to accumulate in the Steffen house molasses and if not eliminated from the system eventually interfere with sugar crystallization and refining. A fair degree of uniformity in molasses worked by the Steffen process is achieved by correlating the amount of foreign molasses intake with Steffen molasses marketed.

Approximately eleven tons (2,640 gallons) of Steffen waste are produced for each ton of molasses worked. The waste is high in total solids, 25,000 to 40,000 ppm, almost all of which are in solution. A good average value for 5-Day B.O.D. appears to be 10,500 ppm. The pH may be as high as 12.6. These data apply to Steffen plants employing the combination, cold and hot, saccharate process.

Condenser Water

This is barometric condenser water from the multiple effect evaporator. It may contain organic material entrained with the vapor from the last effect. Condenser water is frequently reused for flume and process water. In such cases, its polluttional effect is accounted for in analysis of other factory wastes. Where the condenser water is not re-used, it appears as a separate waste. Data obtained on the volume and character of condenser water are given in Table 1. Evaporation of Steffen waste produces additional condenser water.

Ion Exchange Regenerant Wastes

There are no known data showing the volume and characteristics of the acid and alkaline wastes from regeneration of ion exchange resins. Obviously these wastes will contain the non-sugar which would normally be found in Steffen waste. It would appear that the pollution load for a beet sugar refinery employing ion exchange treatment of second-carbonation juice should resemble the waste from a Steffen plant more closely than from a straight house.

Miscellaneous Wastes

Other wastes of a comparatively minor nature are those from washing filter cloths, equipment, floors, and from the testing and control laboratory. Sanitary sewage should be separated from process wastes.

Polluttional Effects

Liquid wastes from manufacture of beet sugar are similar to those from other food processing industries. Oxygen depletion and sludge deposits are common damages to the receiving waters. Destruction of normal aquatic life and severe odor nuisances have resulted from promiscuous discharge of these wastes. The high lime content of beet sugar wastes may impart sufficient hardness to the water to be detrimental to its subsequent use. Relatively high temperatures encourage biological growth and reduce the oxygen-carrying

capacity of the stream.

Remedial Measures

The beet sugar industry being a seasonal industry and operating on a narrow margin has been forced to take a realistic view of its stream pollution problems. Although several methods for abating pollution have been developed and applied on plant scale, there is no unanimity of opinion in the industry regarding the preferred approach. Concerted effort is being made to solve these waste problems through changes in process rather than to install costly waste treatment systems. Remedial measures which have proven successful in varying degrees include: elimination, segregation and reuse, by-product recovery, and waste treatment as a last resort.

Elimination

(1) Pulp Screen Water

This waste can be eliminated by the continuous diffuser together with a mechanical conveyor which will transport the drained pulp from the diffuser to the presses. This precludes the practice at some plants of deliberately diluting the pulp so that it can be pumped as a suspension. Although the great majority of existing plants employ the cell type diffuser, the trend in new construction and remodeling is toward the continuous diffuser.

(2) Pulp Silo Drainage

Discharge resulting from storage of wet pulp in open pits has proven a major pollution source. Prompt pressing and drying of the pulp not only eliminates this waste but also substantially increases the yield of beet pulp cattle food. The pulp press water which is produced introduces another problem but of greatly reduced magnitude.

Segregation and Reuse

Recirculation and reuse hold considerable promise of economical solution to

several of the most important beet sugar wastes. The ever present danger of serious process interference has been a deterring factor to reuse. However, during recent seasons valuable plant operation data have been obtained which seem to favor reuse as a method of handling the major wastes.

(1) Flume Water

Recirculation of flume water is being successfully practiced at a number of plants. Screening and plain sedimentation provide clarification satisfactory for reuse. Some factories use short time detention basins equipped with sludge removal mechanisms while others pass the waste through a lagoon in which settleable solids are allowed to accumulate. The sludge concentration as pumped from the settling basin may be as low as 1.5% solids of which about 25% are organic. The amount of silt adhering to the beets depends very largely on the type of soil in the beet producing area and on weather conditions prevailing during harvest.

Soluble solids and finely divided material build up in the recirculated water. Following stabilization of operation, effluent from the sedimentation basin has been observed to have a total solids concentration of 0.5% and a 5-Day B.O.D. of 1,300 ppm. Some operators have reported offensive odors developing in recirculated flume water. Intermittent chlorination of flume water has proven effective in controlling these odors. Clean water taken into the system to offset that removed with the sludge tends to keep the flume water fresh.

(2) Pulp Screen Water and Pulp Press Water

These wastes have been used as diffusion battery water supply for some time by European factories and more recently in certain United States plants. The greatest single impelling force for re-using pulp screen and pulp press water is stream pollution abatement. Numerous advantages are claimed and

several possible disadvantages are recognized. The proposal continues to be controversial with favorable reports apparently predominating.

Advantages claimed for reuse as diffusion water are:

- Recovery of sugar and pulp.
- Conservation of heat.
- Reduction in fresh water required.
- Economical method of waste disposal.

Possible disadvantages to reuse which have been cited include:

- Suspended matter might obstruct flow around cassettes.
- Interference with diffusion of sugar from beets.
- Increase in non-sugar might retard crystallization.
- Detrimental effect of thermophilic organisms.

Treatment of these wastes prior to reuse as diffusion battery water includes efficient removal of suspended solids and destruction of thermophilic bacteria. Suspended solids have been effectively removed by screening through a 30 x 40 mesh vibrating screen. Plain sedimentation has likewise been reported satisfactory. Thermophilic organisms in the diffusion water, if not controlled, produce objectionable odors, convert sugar, cause gas binding in the diffuser, and create low pH conducive to corrosion. Chlorination and heat treatment have both been successfully employed on plant scale. The efficacy of lime treatment has been demonstrated in a pilot plant.

Although efficient removal of suspended solids from these wastes is deemed advisable prior to reuse as diffusion water, plants have been operated with inadequate screening and very short retention periods. The literature records one factory returning water from the faenger screen, following chlorination, directly to the diffusion battery supply. The most obvious operating difficulties resulting from inefficient solids removal were clogging of return pipe

lines and excessive chlorine demand. The very fact that reasonably satisfactory diffusion is possible under these adverse conditions tends to discount some of the concern associated with reuse.

Plant scale studies with chlorine treatment indicate that chlorine dosages of 25 to 60 ppm in the pH range of 5.5 to 7.0, followed by sedimentation, permit satisfactory reuse of pulp screen and pulp press water as battery water supply. The chlorine was reported to produce some flocculation with improved clarification. The chlorine dosage is influenced by the contact time and solids concentration of the recirculated water. Total solids in recirculated water at one plant was 8,750 ppm at the end of the season.

Lime or acid treatment and sedimentation of these waste waters may be expected to remove a large per cent of the suspended solids. Acid treatment of pulp press water preliminary to reuse is reported widely practiced in Sweden. The literature reports that recovery of sugar was not affected by reuse of pulp screen and pulp press water in fifteen Swedish factories. Certainly there is a potential recovery of additional sugar. Sugar contained in the waste water reintroduced into the system should appear either as increased sugar yield or in the molasses. This theory is based on normal sugar losses in other factory wastes.

In one plant pulp press water was heated to 73° to 75° C. and added to the battery supply tank where it was mixed with fresh water and a temperature between 60° and 65° was maintained. No deleterious bacterial activity was observed. These temperatures attain the best balance between pulp losses, water introduced to the battery, and pulp press work. It would be possible with continuous diffusers to introduce pulp waters a short distance ahead of the point where spent cassettes are withdrawn. This procedure would minimize solids build-up in the reused water inasmuch as the reused pulp water is purged from the pulp by fresh water prior to the pulp leaving the diffuser.

The reuse of pulp screen water and pulp press water is not limited to use in the diffusion process. A portion of these wastes may be used to make the lime cake slurry. Likewise, a portion may be used to dilute molasses in the Steffen process. In this operation, the pulp water may be treated with lime and settled prior to mixing with the molasses. This produces another sludge which must be dealt with. If not treated before such reuse the precipitated material will appear in the lime cake wastes of raw juice purification. In either case soluble impurities are transferred to the Steffen waste.

Elimination of wastes by reuse of pulp and pulp press water is qualified by the transfer of non-sugar pollutants to other factory wastes. Maximum effectiveness of such reuse will be achieved only by application of remedial measures to all wastes concerned.

(3) Lime Cake.

A number of foreign plants were reported calcining the lime cake and re-using the lime. Lime makeup was reported as 25%, indicating some discard. Burning of the lime cake would encourage handling it in the comparatively dry state as removed from the filter presses. The cake contains about 50% moisture and can be handled by belt conveyor or other mechanical means. The practice of diluting lime cake to a slurry is an expedient to handling.

(4) Condenser Water

Where conservation of water is essential, barometric condenser water is passed over a cooling tower and recirculated. Cooling and recirculation of condenser water is reported at some factories in England with chlorination of the water to control slime growth.

By-Product Recovery

By-products from beet sugar manufacture are confined to molasses, beet pulp, and recovery from Steffen waste. Information pertaining to pulp and molasses is given in a previous section designated "Products."

(1) Steffen Waste

The most promising solution to the Steffen waste problem is to concentrate the material in multiple-effect evaporators and to incorporate the sirup with the beet pulp, thereby enhancing its nutrient value. Experimental work has been conducted with both evaporation and feeding of the enriched beet pulp. Results of this research show promise of profitable by-product recovery.

Monosodium glutamate is currently being produced at plants in California and Ohio. This process uses the Steffen waste, which has been concentrated to between 60 and 70 per cent total solids, and produces glutamic acid by caustic hydrolysis, acid treatment of the hydrolysate, refining, and crystallization. The end liquor from the monosodium glutamate process has a solids concentration of 65% and a 5-Day B.O.D. of 378,000, a formidable waste. Studies are being made with the view of incorporating this end liquor on the beet pulp as a fortifier for the pulp stock food.

Steffen waste also possesses potash and nitrogen constituents in concentrations inviting recovery. During World War I, recovery of these constituents proved economically sound.

Waste Treatment

Considerable research has been conducted in the treatment of beet ~~sugar~~ wastes, both individual and combined. Seasonal operation causes overhead to be very costly for any form of beet sugar waste treatment.

(1) Flume Water

Treatment consists of screening, grit removal, sedimentation with or without coagulants in tanks equipped for continuous sludge removal, and either vacuum filters or sludge ponds. A retention of 80 minutes in the sedimentation basin has been recommended. Removals by this treatment have been reported as high as 92 per cent suspended solids and 42 per cent 5-day B.O.D. Steffen

waste has been reported satisfactory as a coagulant for flume water.

Settling of flume water waste in ponds before discharge is commonly practiced. Ponding is effective in removing suspended material, but no consistent significant reduction of B.O.D. is accomplished. Flume water withdrawn from recirculating systems could well be combined with other residual plant wastes and subjected to biological treatment, which treatment plant could be operated the year 'round.

(2) Lime Cake Slurry

This waste is commonly stored in ponds providing several days detention. Such treatment removes practically all of the suspended solids and gives a substantial reduction of B.O.D. The volume of this waste is such that lagooning is feasible.

(3) Pulp Screen Water and Pulp Press Water

Even though re-use of this process water as diffusion battery water supply is generally accepted, such a process modification will be gradual in the industry and these wastes must be reckoned with in the interim. The fine screening materially reduces the concentration of these wastes and yields quantities of pulp having economic significance. Vibrating screens, 30 x 40 mesh, have been successfully employed. This type of screen has a capacity for screening 22 gallons per square foot per minute of the combined process wastes.

Coagulation of pulp screen and pulp press water with lime has been practiced, using a dosage of 500 to 600 ppm CaO . Lime treatment requires a chemical feeder, mixing chamber, coagulation tank, sedimentation basin, and sludge disposal facilities. Coagulation for 20 to 30 minutes and a settling period of 2 hours has been recommended. Such treatment produces a water-clear effluent and B.O.D. reductions as high as 47 per cent are reported. Other studies have shown as low as 30 per cent average 5-day B.O.D. reduction for

lime treatment. In any event, the effluent is still highly objectionable, in that the B.O.D. remaining is high and the treated waste is caustic, containing considerable calcium.

Natural purification of these wastes can be accomplished by extended lagooning. However, the volume involved requires large lagoon areas which frequently give off obnoxious odors. The lagooned wastes should be amenable to biological treatment with high-capacity trickling filters.

(4) Condenser Water

It is common practice to use condenser water in process. Under certain conditions, discharge of warm condenser water might be objectionable. Spray ponds have been observed for cooling this water prior to discharge.

The most optimistic results through elimination, re-use, and by-product recovery will still leave miscellaneous wastes, residual liquid wastes from recirculation systems, and lagoon supernatant requiring treatment except in those locations where there is an abundance of dilution water. Uniform discharge of lagooned wastes through biological treatment units throughout the year has been applied to similar organic wastes and has been considered for residual beet sugar wastes.

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